On the Performance of Objective Metrics for Omnidirectional Visual Content

Introduction

• Conventional 2D objective metrics only are able to assess the quality of 360-degree videos under same projection model.

• Objective metrics for 360-degree content are proposed, such as V-PSNR, S-PSNR, Latitude weighted-PSNR, WS-PSNR and CPP-PSNR.

• However, the performance of these objective metrics is unknown.
Goal

• To assess the performance of objective metrics designed for 360-degree content against subjective metric, namely mean opinion score.

• Additionally, a comparison to the performance of conventional 2D objective metrics has been carried out.
Dataset

- 4 uncompressed equirectangular images represented in YUV color-space format with 4:2:0 chroma sub-sampling
- down-sample the images to 3000x1500 pixels and then map to cubic projection
- both equirectangular and cubic images are compressed with 3 codecs, namely JPEG JPEG 2000 and HEVC
- 4 target bitrates, 0.25 0.50 0.75 1.00 bits per pixel
Testbed

- Google Cardboard HMD equipped with mobile platform (iPhone 6)
- Software application developed with Swift

Experiment

- 25 males, 15 females, 40 subjects in total
- testing images are presented to subjects and voting is performed after each viewing
- images are assessed using ACR-HR method with five-grade quality scale (1-Bad to 5-Excellent)
Subjective Results

- Higher performance of HEVC and JPEG 2000 when compared to JPEG at lower bitrates

- Lower scores for cubic mapping at medium bitrates and same scores as for equirectangular mapping at high and low bitrates

Fig. 3: MOSs with CIs obtained using ACR-HR method for compressed omnidirectional images. Red (solid) line represents HEVC encoded content, blue (long-dashed) - JPEG 2000, and green (short-dashed) - JPEG. Equirectangular projection is depicted with circles and cubic mapping - with triangles. Filled area between two horizontal lines corresponds to the 95% confidence interval of the hidden reference for each projection (red for equirectangular, cyan for cubic).
Objective Evaluation

- Conventional 2D objective metrics:
  - PSNR
  - SSIM
  - MS-SSIM
  - Visual Information Fidelity in pixel domain (VIFp)

- Objective metrics designed for 360-degree visual content
  - Spherical PSNR (S-PSNR)
  - Weighted S-PSNR (only for Equirectangular)
  - CPP-PSNR (CPP is equal area projection)
Results

Fig. 4: Mapping of objective scores to subjective ratings. Triangles represent cubic projection, circles represent equirectangular projection. Different contents are marked with colors: "Harbor" - red, "Kite Flite" - green, "Pole Vault" - cyan, "Skateboard Trick" - magenta. Solid black line depicts a logistic fitting.
Results

Overall, objective metrics designed specifically for omnidirectional visual content do not show better performance when compared to common objective quality evaluation measures.

TABLE III: Standard performance indexes. Subcolumns A, B, and C, represent the results for equirectangular, cubic, and both projections computed over all the contents, respectively. Subcolumn D shows an average of coefficients computed for each content separately.

<table>
<thead>
<tr>
<th>Metric</th>
<th>PLCC</th>
<th>SROCC</th>
<th>RMSE</th>
<th>OR</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
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<td>PSNR</td>
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<td>VIFP</td>
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<td><strong>0.8994</strong></td>
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<td>S-PSNR</td>
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<td>0.8392</td>
<td>0.9168</td>
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<td>WS-PSNR</td>
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<td>-</td>
<td>-</td>
<td><strong>0.9583</strong></td>
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<td>CPP-PSNR</td>
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<td>0.8521</td>
<td>0.8658</td>
<td>0.9467</td>
</tr>
</tbody>
</table>
Conclusions

- In this paper, they conduct a subjective evaluation experiment on 360-degree images.

- Analysis of the obtained subjective and objective scores indicates moderate performance of investigated metrics for 360-degree visual content.